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## ART. III.—ABSTRACT SCIENCE IN AMERICA, 1776–1876.

IF we were called upon to decide in what field of purely intellectual effort a people, situated as ours were at the beginning of their national existence, would be least likely to distinguish themselves, we should hardly hesitate to say, the field of abstract science in all its parts, physical, political, and intellectual. One reason for this conclusion lies upon the surface. That precise knowledge of the first knowable principles which underlie the phenomena of nature, and that seemingly useless tracing of the ideas of Nature through the minutest details of her operations, are, among important intellectual employments, those of which the natural man, though enlightened, least feels the want. He cannot live in society without feeling the want, first, of a code of laws, and then of a knowledge of law in general. He cannot advance far in intellectual capacity without feeling the want of a literature with which to beguile his weary hours, nor can he read much that is good without appreciating the difference between the good and the bad. It needs no rare and peculiar gifts or taste to be enraptured with the charms of music, and with the beauties of form and color. But how will he ever learn to care for the seeming technicalities of scientific investigation? Undoubtedly, a curiosity to know many things respecting the phenomena of nature will arise as naturally as will the love of literature and art, and will be as widely extended. We cannot imagine a man loving to read without feeling some curiosity respecting the nature and purpose of the heavenly bodies, while a certain amount of knowledge respecting animals and plants is necessarily acquired by every backwoodsman. But the acquisition of knowledge of this class does not constitute scientific progress. When we touch upon the consideration of the circles of the celestial sphere, the atomic weights of the chemical elements, the homologies of corresponding parts of the various species of animals, or the laws of hereditary descent, and especially when we enter upon that minute analysis of every-day subjects which is at the same time so necessary to their philosophic comprehension, and so

distasteful to the ordinary mind, our hearers will rapidly disappear.

We have thus an obvious cause why, in a country like ours, scientific investigation worthy of the name should commence only when a very advanced point of intellectual development had been reached. But an allied, though less obvious element enters among the causes of scientific progress which is worthy of very serious consideration. The intellect of a nation may exhibit peculiarities, as well as that of an individual, leading to its being eminently successful in some directions, while wholly failing in others. We do not here refer to well-known general differences in the intellectual power of different races, the Caucasian and the Mongolian, for instance, but to differences of special faculties or tastes between people whose general powers are on the whole equal. A study of the history of modern science will show plenty of instances of the diffusion of special powers among a large part of a nation or of their seeming total absence, for which it is extremely difficult to account. One such is afforded by the development of the theory of gravitation. The establishment of universal gravitation was an achievement of the British intellect, as well as of Newton, since several of his countrymen were very little behind him in the course of thought which led to this result. The superiority of Englishmen in the powers of investigation necessary to establish the theory would seem to be evinced by the readiness with which they perceived its truth and traced its effects, while a generation of Continental mathematicians occupied themselves with puerile objections to it. But, with the publication of the *Principia*, the development of the subject came to a dead stop in England, and while Clairant, Lagrange, and Laplace were working out the results of Newton's discovery, there was scarcely an Englishman who could even understand their writings. The liberal rewards by which the British government have sometimes so honorably expressed the national appreciation of the men who have made gravitation instrumental in the determination of longitude at sea have all gone to foreigners. Although the British Nautical Almanac is mainly founded on data derived from the Greenwich observations, the labor of putting these data into a tabular shape to be used has, during the entire century, been performed by foreigners.

We see here a striking difference between the intellectual productions of two peoples,—a difference showing itself through two centuries, and yet arising from what might seem as too slight a difference in the characters of the intellects themselves to require notice. The English intellect was perhaps the more scientific of the two; it was more ready in grasping the ideas of nature, in seeing the correlations of natural phenomena, in distinguishing between the relevant and the irrelevant in propositions, and in freeing itself from the trammels of philosophic systems when it turned its attention toward the external world. In short, it was generally superior in everything connoted by the word “sagacity.” But, the general idea of nature once grasped and expressed in mathematical language, the Continental intellect was that best adapted to tracing it to its results by deductive operations. These required powers of minute analysis, of close concentration upon minute points, and of patient endurance while carrying through long trains of thought, which the English intellect did not possess, and has never since acquired.

A critical history of scientific thought during the three centuries which have elapsed since the revival of science would, no doubt, show many other fruits of the difference we have sought to elucidate. It would be seen that in everything requiring sagacity, in pregnant suggestions, and in discoveries reached by induction, England would be ahead of any other nation; while the development of the discoveries, or at least every branch of the development which required patient industry and minute analysis, would have been found left to other nations. The illustration need not be confined to physical science. Political economy, as hitherto developed, is just that branch of applied thought, if we may use the expression, which most requires sagacity for its apprehension and application; and this quality is seen pre-eminently in the large comparative ratio of sense to nonsense in the mass of English writing on the subject.

One disposed to study what we might call the intellectual natural history of nations would find an instructive subject for investigation in the different views of Darwinism prevalent in the four great intellectual nations of the world. In the land

of its origin it is a subject of fierce controversy between the religious world on the one side and the scientific one on the other; in Germany, received with universal applause as one of the great philosophic triumphs of the century; in France, so utterly groundless a piece of speculation as to be unworthy of the attention of a biologist; in America, received by naturalists, but viewed by the public as something on which it is quite incompetent to pass judgment.

If, now, one enters upon a critical examination of the judging faculty of the American people, as shown by their reasoning on subjects of every class, one can hardly avoid being struck by a certain one-sidedness in its development, having an important bearing on its fitness for scientific investigation. Within a certain domain, usually characterized as that of practical sagacity and good sense, they have nothing to be ashamed of. Where the conclusion is reached by a process so instinctive that it is not reduced to a logical form, and where there is no need of an analysis of first principles, we may not unfairly claim to be a nation of good reasoners. But, if we pursue any subject of investigation into a region where a higher or more exact form of reasoning is necessary,—where first principles have to be analyzed, and a concatenation of results have to be kept in the mind,—it must be admitted that we do not make a creditable showing. It might almost seem as if the dialectic faculty among us had decayed from want of use. The plain “common-sense” of the fairly intelligent citizen has in most cases so completely sufficed for all the purposes where judging capacity was required, that the need of more exact methods of thought has never been felt by the nation at large.

There is hardly a branch of our intellectual activity in which the close and critical observer will not find plenty of illustrations of the peculiarity which we have described. Taking as our standard of comparison the three leading intellectual nations of Europe, England, France, and Germany, the latter alone can compete with us in provision for, and appreciation of, the education of the masses. But when we look at the higher education,—whether that of the polished gentleman, the statesman, the engineer, or the financier,—we find ourselves far behind those countries in both the provision and the

appreciation. Our elementary text-books are as good as any. What few we have on the higher logic and the more advanced branches of mathematics are very deficient, and, in the case of the mathematical text-books, betray a lack of clear and accurate thought which would not be tolerated in a teacher in the other countries we have mentioned. If we examine our politics and jurisprudence, the general astuteness of our public men, their faculty of adapting means to such ends as are immediately in view, and their successful diplomacy, cannot be questioned. But where in our legislation shall we find any effort to look beyond the necessities of the immediate present? What shall we say to the continued presence of usury laws in our statute-books, and to the rarity with which a man is found in public life with the logical acumen necessary to see through the fallacies of the protection theory? What a disheartening picture of our jurisprudence would be found in the mere citation of the various legal decisions to which the legal-tender acts have given rise!

This national one-sidedness of the judging faculty has a very important bearing on the state of science, because the successful cultivation of the higher regions of science, no matter in what department, requires the highest development of that faculty. Neither instinct nor good sense will alone suffice to comprehend the more recondite workings of natural law. It is true that a large majority of the more important applications of scientific principles may be made, and a great deal of valuable scientific work may be done, without the highest development of the dialectic faculty. But such applications and such work do not constitute the highest employment of the scientific investigator. It is, therefore, very naturally to be expected that the development of the higher branches of science in our country should be marked by the same backwardness which characterizes the higher forms of thought in other directions; and that, however eminent we might stand in the lower branches, we should find ourselves far behind in the higher ones.

The same subject may be viewed from a slightly different standpoint. No two sets of ideas are more completely antagonistic than those which animate the so-called "practical man"

of our country, and those which animate the investigator in any field which deserves the name of science or philosophy. The facts that, in its methods and results, nothing is really more practical, in the best sense of the word, than modern science, and that it is to the discovery of natural laws by men of science that all the benefits which the practical man most highly values are due, do not in any way lessen this antagonism of fundamental ideas. The first condition of really successful and important scientific investigation is, that men shall be found willing to devote much labor and careful thought to that subject from pure love of it, without having in view any practical benefit to be derived from it as an important consideration. The true scientist takes as much interest in the geography of the moon as in that of the earth, and studies the minutest animalcule as zealously as man himself. The very fact that utility is ostensibly ignored gives a breadth to scientific research which it would otherwise never have had, and to which the discoveries which have been of such incalculable utility to mankind are really due. If the practical man should object to useless knowledge as dross, we should reply, that he cannot have the gold without the dross; that such a thing as a discoverer of useful natural laws and an ignorer of useless ones is unknown in the world's history, and will probably remain so. In fact, so far as the discovery of new laws is concerned, it is impossible to say whether a discovery will or will not be useful until after it is made, — perhaps generations afterward; therefore he who waits to see the utility before seeking for the discovery will never discover at all.

The early settlers of our country, with whom the great problem of life was to overcome in a hard struggle for existence, could not be expected to cultivate such a taste for science as we have described. To suppose that they would encourage and support any of their number in laborious investigation for the mere sake of knowing, would be to expect of them something more than human. Indeed, it would be almost a violation of natural law to expect the development of a trained investigator in such a state of society. It is therefore very gratifying that American science can point to so worthy a man as Benjamin Franklin as its father. Commencing as it did with so

capital a discovery as that of the identity of lightning and electricity, it might almost have seemed to come into life full grown ; and if Franklin had had coadjutors and successors comparable to himself, it might have soon been in a position to compete with the science of Europe. When we seek for such successors as he had and compare their circumstances with those under which rapid advances have been made in a knowledge of natural laws, we shall see one reason why the growth of the tree planted by Franklin was so slow and stunted.

One of the first things which will strike us in the history of modern scientific investigation is that such investigation is seldom pursued with any great success by isolated men. We do not here speak of the work of those rare characters who may be said to take advantage of some favorable epoch in the progress of thought, such as Copernicus, Newton, and Linnæus, but of that gradual working out and developing of ideas which constitute the great body of scientific doctrine. Men like those we have named might arise in any age which should be ready for them, but, so thoroughly is every field now explored and reduced to technical forms, that we can see no further opportunity for isolated genius to work out radically new ideas. The immense advance which has been made since the time of Newton has been effected almost entirely by men working together in close associations. The mutual attrition of ideas, the competition of rival workers, the zest gained by intercourse with kindred spirits, though of a lower order of genius, are all most important factors in such advance. We thus find that the formation of the Royal Society of London, and of the Academy of Science in France, marks the epoch of the revival of science in Europe. During the two centuries which have since elapsed, the history of these associations has been almost identical with that of the knowledge of nature in their respective countries.

From the time of Franklin the progress of American science depended very largely upon the success with which close association could be maintained among men of learning. He made an excellent beginning in the establishment of the Philosophical Society. Among the early members of this society the only name at all eminent in the field of science, besides



that of Franklin, which has descended to us, is that of Rittenhouse. The latter had not, any more than his great contemporary, the advantages of a thorough educational training, much of his youth having been spent in agricultural labor. Still, his circumstances were not such as to debar him from intellectual pursuits, and he made himself as complete a master of the physical science of his times as was possible to one so situated. Among his fellow-citizens much of his reputation was due to his clocks and orreries; but it is his skill as a practical astronomer which has carried his name down to posterity. Having no public observatory, occupying no position which made it part of his duty to devote himself to science, supporting himself by his own resources, and working principally with instruments of his own construction, it is not to be expected that his work would compare in extent with that of a more favored astronomer. But, in general precision, the first requisite of astronomical observation, his work was well up to the average of his time. His observations of the celebrated transit of Venus in 1769 have every appearance of being among the best that were made, the care and skill devoted to them being as great as elsewhere, while the meteorological conditions were unusually favorable. It is remarkable that his observations were continued through at least the first half of the Revolutionary War.

That the early days of the Republic should prove unfavorable to the thorough prosecution of philosophical research of any kind was to be expected. The mind of the nation was too much occupied with the more pressing necessities of the situation to admit of any great activity in a direction not leading to immediate practical results. Still, some circumstances show that the intellectual spirit of the nation was not at all diminished by the terrible struggle through which it had passed. In 1783 the Legislature of Pennsylvania made a grant to the Philosophical Society of four hundred dollars,—a mark of official appreciation which we doubt whether such a body has since received either from the general government or from that of any State. Within ten years of the acknowledgment of American Independence the same society erected for its own use what, from the point of view of that time, was a “neat, convenient, and spacious edifice.” Few, indeed, are the scientific societies

in this country which have been able to do as much. The public appreciation of Rittenhouse was shown by the numerous public employments which were almost forced upon him, which, as in the case of Franklin, deprived him of the time necessary for scientific research.

If, from such a cause as public appreciation, Franklin and Rittenhouse were in a certain sense lost to science, we shall find it difficult to believe that the development of American science would thereby be retarded. The natural result would seem to be that many of the rising generation would have been incited to emulate them in their career. The spirit we have described was eminently favorable to such a result. Most astonishing is it then to find that, far from any such progressive development as would have been looked for, far even from science in what was then its principal centre remaining stationary, the tree planted by the two men we have named not only bore no fruit, but absolutely withered away. For half a century there was nothing worthy of the name of national science, nothing on which the public could look, and say with pride that it was a product of our educational system or of our effort to promote the knowledge of nature. Two or three men of genius arose, but they received no stimulus to exertion from the public, or, if they did, their works betray the want of attraction with other men of like pursuits able to criticise them. A suggestive circumstance is, that they were in the main self-taught.

During the interval of which we speak the sciences the cultivation of which would have seemed most natural in this country received no more lasting impress from American investigation than did others. The flora and fauna of the new country must have offered a field of research tempting to the scientific taste and remunerative in a practical point of view. That it was wholly uncultivated it would be incorrect to assert, but none of its cultivators did anything to leave a permanent impress on science. Not only did no creative genius show itself among them, but it is questionable whether any of them were as much abreast of the European science of the time as were Franklin and Rittenhouse. That our country should have produced no Lavoisier, Cuvier, or Jussieu is something which cannot greatly surprise us, but why should we not have had plenty to adopt,

to criticise, or to develop their ideas? If we knew exactly how long it took the new systems of classification to supersede that of Linnæus throughout our country, the knowledge would have much historical interest, but would not, we fear, be at all provocative of national pride. The fact is that our science was little more than a timid commentary on European science, in which certain models, supposed to be standards, were followed in the same way that the schoolmen of the Middle Ages followed the philosophy of Aristotle.

The thorough investigation of the cause of this period of apparent intellectual darkness would require us to enter into the spirit and the history of the times to an extent possible only to the professional historian. Yet some consideration of the state of things indicated by it may not be out of place.

To insure the successful cultivation of science in a country two things are necessary; the cultivators must be born, and they must be nurtured. In the case of those rare characters of whom a country hardly produces more than one a century, the nurture may enter as a very small element, and may therefore be of a very imperfect kind; still it must enter in some form. To expect that the greatest genius, if kept until middle age in the backwoods, away from both books and living teachers, would ever produce anything great in the way of technical scientific research, would be hopeless. We may find in the general state of public opinion during the period of which we speak a reason why men of pure research were not nurtured. But may there not also be something in our country unfavorable even to the birth of men of the highest scientific genius? Or, taking into account the one-sidedness in the general development of the American intellect which we have endeavored to describe, may it not be that the analytical power which traces the laws of nature through the complex conditions under which they operate is partially replaced by the inventive genius which has taken the lead in giving the world steam-navigation, the telegraph, and the sewing-machine? If a wide diffusion of the power in question were necessary to our being a scientific nation, we might have to admit that such has been the case with us. But, since the requisite number of philosophic investigators is, in any case, very small, the fact that

the general mind of the nation may not be inclined in the scientific direction does not preclude the possibility of this small number of inquirers being born.

The question of the influence of race and descent is largely involved in the one we are considering. If we consider the views of hereditary genius maintained by Mr. Galton to be correct in the case of the genius of the scientific investigator, we must consider the descent of the American nation to be unfavorable to the production of such genius. The class of philosophers and men of science has not been fairly represented, even in proportion to its small numbers, among the emigrants who have come over to our shores. The necessary result is that, as compared with the intellectual nations of Europe, a disproportionately small part of our population can count philosophers and investigators among their ancestors.

But, however true the theory of hereditary descent may be, when we consider that general force of character which makes a man felt among his fellows, the preponderance of evidence is decidedly against its extension to scientific genius. The latter, though confined to a single race, seems to be almost entirely sporadic. In a few cases it may be traced from father to son; we question whether it has ever been traced further. It seems as if whatever peculiarity of organization it may be connected with is of too slight a character to be either perpetuated or insured against among the offspring of intelligent people. There is nothing about its possessors which causes them to strike the minds of others. In their appetites and their organizations, and indeed in everything outside the sphere of accurate thought, they are a sufficiently commonplace class. Altogether there is no sound reason for believing that the class in question is born in any smaller proportion here than in other intellectual nations, and whatever apparent deficiencies we may find are probably due to defects of nurture. Returning to the consideration of American science between 1790 and 1840, we find some confirmation of the views we have expressed in the fact that during this period we find several American names of the first rank so far as regards mental power, who, if they have failed to fill a position corresponding to their genius, have done so only in consequence of the circumstances by which they were surrounded.

As representatives of the small class of which we are speaking, we may take Bowditch, Bache, and Henry, of whom it is remarkable that not one received a college education. Notwithstanding the singularly unfavorable occupations of his early days, there was hardly a man living who was a more complete master of the celestial mechanics of his time than was Bowditch. When we consider that he acquired this mastery by his unaided efforts, from pure love of the subject, while engaged in mercantile business or seafaring pursuits, we can hardly refuse him, in genius, a place alongside of Laplace and Hansen. But he was never stimulated by the attrition of kindred minds, as he would have been at Paris or Berlin, and, in consequence, his original investigations in no way correspond to what we might have expected from him had he been born in Europe. It may be that his best work was done in stimulating the study of the higher mathematics among his countrymen. The work for which he will always be best known is his translation of the "*Mécanique Céleste*" of Laplace, and it is by its effect in this direction that it must be judged. As a monument of industry, and a proof of Bowditch's mastery of the subject, this work cannot be surpassed. To adding anything to the subject it made no claims, its object being mainly an educational one. Its most remarkable feature was a minute and detailed commentary, in which every difficult operation was explained, and by which a student would be able to follow the reasoning of the author, without any higher mathematical knowledge than the imperfect native text-books of the time would afford him. This commentary had undoubtedly the effect of enabling many to read the work who would not otherwise have found themselves able to do so; yet we cannot concede that this was the most advantageous form in which the help could have been given. No one who could not read Laplace without the Commentary would derive any real profit from reading him by its aid, while he might derive profit by studying more elementary subjects. It was like furnishing a classical author with an interlinear translation; that the unfavored student might read him without studying the grammar of his language. This Commentary, as well as some other of Bowditch's writings, betrays the want of that inspiration which

comes from immediate contact with the masters of the subject. Could he, in youth, have spent but a single year in the drill of a European university, the effect would have been seen in all that he did.

It is strikingly illustrative of the absence of everything like an effective national pride in science that two generations should have passed without America having produced any one to continue the philosophical researches of Franklin. The natural effect of the success of such a man, in such a direction, ought to have been that studies and experiments in electricity would have had an especial interest for his countrymen of the next generation, and that electricity would thus have become, in some measure, a national subject of research. But not the slightest trace of such an effort showed itself. Until Henry commenced his experiments, there was not an electrical investigation published in the country which the present time has any object in remembering. As with American scientists in general, Henry's published investigations do not give an adequate idea either of his skill or of the amount of research he actually undertook, without any of those surrounding circumstances which, in other countries, stimulate men to research. Had he been in the situation of Faraday, he might have gained the same name. If he lacked any of Faraday's skill in designing experiments, he would have made it up in accurate grasp of the hypotheses which the experiment was to prove or disprove. His discovery of some of the laws of electricity, which made the Morse telegraph possible, is well known, though, as usual, popular attention was entirely concentrated upon the inventor who put the laws into practice, while the discoverer was nearly forgotten. Whatever he might have done in the field of original research, his activity in that direction necessarily diminished greatly when he took an administrative position, in which his functions were to stimulate others.

The career of Bache was not unlike that of Henry. He was less self-taught than either of the other representative men we have named, being a graduate of West Point. Like most of the great representatives of American science, the activity of his early years in scientific research was directed

into a different channel by the position he occupied during his later years. The conduct of a series of physical experiments requires an amount of careful, leisurely thought, which it is quite impossible for one filling the position of Superintendent of the Coast Survey to devote to them.

From what we have said of the history and labors of the principal distinguished representatives of American science, it will be seen that the comparatively imperfect development of our thought in the direction of science is not due to any lack of native ability. However averse to the precision of scientific thought the general mind of the nation may be, it produces a sufficient number of great minds to satisfy the needs of its intellectual position. But we see very clearly a great lack of continuity of work among our leading scientific men. Few, indeed, are the American investigators who have followed up their subject during their whole lives, working it out from step to step, as Europeans have done. Sometimes their failure has arisen from lack of persistence, experience showing that success would be accompanied by no reward proportionate to the labor bestowed, but more often from the less elevated but more pressing duties of life rendering it impossible to devote the necessary thought to the pursuit of research. Even when the duties are those of a professor's chair, in which research would seem the most appropriate employment of leisure hours, it has commonly happened that the duties of the position absorbed the entire energies of the occupant.

The science of which we have thus far sought to give a clear idea may be said to stand entirely on its own merits as a part of the intellectual life of the nation. Its laborers were men who engaged in it from pure love of the subject, proceeded in much their own way, and ceased when circumstances diverted their energies into other channels. But in no civilized country is it thus left to stand entirely alone; for although a government may do nothing especially looking to the promotion of pure science, there are so many important applications of scientific principles necessary to the public welfare, that some regard must be paid to applied science. And it is soon found impossible to make a really useful application of science, without such a thorough investigation of the subject in hand

that the progress of pure science will thereby be promoted. A complete idea of the progress of our national science cannot therefore be formed, without considering its relations to our government, and the measures the latter has taken in promoting it.

The leading governments of Europe have generally taken a pride in promoting scientific knowledge, and it was to the efforts thus arising that we may trace the scientific revival of the seventeenth century, which in its progress has exerted so important an influence on our civilization. In the beginning no merely utilitarian end was in view. Monarchs like Louis XIV. and Frederic the Great were desirous of having their reigns rendered illustrious by being connected with the progress of intellectual activity, of all kinds, and so sought to surround themselves with men of eminent reputation. Thus arose or flourished the academies of science of the principal European capitals. The general policy with respect to these bodies has not greatly varied. The members generally receive a small pension or other stipend from their government, not to support them, but to secure them against absolute penury under all circumstances. The most important aid furnished by the government comes in the shape of the means of making and publishing researches. In return the academy is the adviser of the government in all matters pertaining to the application of science in its administration.

Of course there are some differences of detail in the organization of these bodies, and in England the difference is so wide that that country cannot be said to have an academy of sciences, in the Continental sense of the phrase. The place of such a body is partially filled by the Royal Society, but the government does not in any way contribute to the support of this society, and does not even assist it in printing its Transactions. Still, its influence with government is not materially different from that of the Continental academies, since, although not formally recognized as an official adviser, it is as constantly consulted as if it were so recognized.

So far as we are aware, there has been but a single occasion in its history in which our government has felt the want of a scientific advisory body. If we were to say that it is one of



the fundamental doctrines of our nation and government, that one intelligent and influential citizen can do anything and everything as well as another, we should be liable to the charge of strong overstatement. But it would be equally untrue to assert that the opposite doctrine was maintained and acted upon. The fact that there are any operations, the conduct of which requires special skill and special training, is one which our administrators generally are very slow to recognize, unless compelled by the force of circumstances. No doubt this is fundamentally due to the general versatility and adaptability of the average American, which in the large majority of cases take the place of skill and special training with entire success. It is therefore not surprising that the government has seldom felt the need of the advice of specialists in matters pertaining to administration, even in those cases where entire success would have seemed to require the aid of the highest scientific knowledge.

We have said that there was one exception to this. When the civil war broke out the government was overwhelmed with inventions of improved machinery of war, the practicability of which could not be judged without the aid of scientific experts. A board of such experts was therefore formed for their preliminary examination. This suggested the idea of a permanent academy, which should examine and report upon any subject of science or art, whenever called upon to do so by any department of the government, and thus arose the National Academy of Sciences, which was chartered by act of Congress in 1863. The future success of this body cannot yet be foreseen, but it has met with several drawbacks in the past. In the first place, although ostensibly organized to perform the functions of an European academy, this object was wholly ignored in its organization. The first condition of such performance is that the members should reside at or near the capital, and that the body should hold frequent meetings. But the members actually incorporated were scattered all over the country, so that more than one or two meetings a year were out of the question. In view of this fact, the question whether, in selecting the members, scientific eminence was the controlling consideration, is hardly worth discussing. In the next place, the charter

contained an absurd provision which prevented the Academy receiving support or remuneration of any kind from the government in return for its services. We say absurd, because the very first condition of the usefulness of the body was thereby violated. What should we think of Congress chartering an academy of law, with the fundamental condition that the members should give their legal services, without compensation, to all departments of the government, in any law-suits in which the latter might be involved? To appreciate the situation, we must remember that the Academy receives no support of any kind, direct or indirect, from the government. If the latter furnished it with a room for its meetings, its offices, or its collections; if it paid the expenses of members attending its meetings; if it printed or circulated the scientific papers read before and accepted by the society, or helped to do so, — the case would not be so bad. One year the printing of these papers was commenced at the government printing-office, but it was stopped, on the ground that the printing was in violation of the condition on which the Academy was founded, because it cost the government money. The general result is, that the contrast between the eminent name of the Academy and the celebrity of its members on the one hand, and its means of doing either harm or good on the other, is ridiculous in a degree of which the members themselves can hardly help being conscious. It is too suggestive of eminent respectability out at the elbows.

We have had a recent example of the entire absence of all necessity for scientific advice in the administration of the government in the origin of the system of weather reports and probabilities by the Army Signal Office. In importance and extent the meteorological system organized by this office has no parallel in the world. Its cost is in the same proportion, far exceeding anything that any European nation ever thought of devoting to such a purpose. Had so magnificent a project, involving such an expenditure, been presented to any other government strong enough to undertake the matter, the first idea suggested would have been that the opinion of the highest scientific authorities on the practicability and importance of the project must be obtained before putting it into execution.

The support and approval of competent meteorologists would have been absolutely necessary, in order to secure the sanction of the government. Yet, so far as the public is aware, not a solitary scientific authority or meteorological expert was ever officially asked either to report upon the scheme or to give advice respecting its execution. The sole responsibility rests with the single military officer who conceived and executed it, and he receives the sole official credit for it.

We wish the reader to consider this fact both in its favorable and unfavorable aspects. We see it in the latter aspect when we consider how completely the men whose studies and researches rendered the prediction of the course of storms possible have been ignored or forgotten when their labors were to be made practically useful. Several of the most able and active of these men were Americans, a few of whom are still living. The favorable side is clear enough, and we have no desire to depreciate the organizing ability shown by the chief signal officer in putting the system into execution, or the liberality shown by Congress in sustaining it.

The most important relations of the government to science have been those growing out of the public works of the former, and especially the public surveys which it has undertaken. One of its earliest wants in this direction was that of a thorough survey of its coasts and harbors, and we find measures to supply this want undertaken early in the present century. The execution of the plan was, however, postponed and interfered with by various causes, which prevented its being earnestly undertaken until 1832. The scientific conduct of this work has been excellent from the very beginning, — a result which is due to the competent hands by which it was organized. Its first superintendent, Mr. Hassler, was a thorough student and an experienced geodesist, who brought to the work the highest ideas of system and accuracy, but did not possess the faculty of securing the good-will of Congress. Under the administration of his successor, the lamented Bache, it became the most perfectly organized survey in the world, employing the most improved methods, and leading to the most accurate results. Among the methods which it took an active part in originating, the most important is that of the determination of

longitudes by telegraph,—a method which has been almost revolutionary in its results. By it a chain of longitudes now extends from San Francisco across the American continent, the Atlantic Ocean, Europe, and Asia, to the Pacific coast of Siberia, with a degree of certainty which would not have been attained in a century by any other method.

Another system of surveys by which the government indirectly contributes to advance the study of science is that of the Territories. When we consider the extent of these Territories, their unknown mineral wealth, their possible capabilities for the support of population and the remuneration of industry, and the necessity of an accurate knowledge of their geography and geology as a preliminary to the development of their resources, it will not appear surprising if increasing attention is devoted to geographical and geological surveys. The character of these surveys has corresponded pretty closely to the scientific development of the country at the time they were made, and a critical examination of them is sufficient to show the futility of the idea that pure and applied science can be successfully divorced. The earlier ones were simple “land surveys,” the object of which was to divide the region over which they extended into “townships” of ten miles square. The Land Office being unable to command the skill necessary to do this properly, geometry was painfully mangled by the unavailing efforts of the government surveyors. If we examine the Land Office maps, we shall find here and there lines running awry to the extent of five, or even ten degrees. As a general rule, however, we shall find a gradual improvement extending through the last forty years. The necessity of passing public criticism results in a constant effort on the part of each survey to command the services of competent geologists, topographers, and astronomers; and this, again, encourages young men to train themselves for such positions. The rivalry between two competing departments of the government for the control of the survey of the Territories — however greatly to be deplored for some of its results — has exerted a good effect in stimulating each party to do the best work; and, on the whole, the general execution of these surveys is as good as could be expected under our administrative system.

We have described and illustrated the generally low state of American science during the first forty years of the present century,—a state which may be described as one of general lethargy, broken now and then by the activity of some first-class man, which, however, commonly ceased to be directed into purely scientific channels. Since 1840 there has been a great and general increase of activity in some directions, which, from some points of view, would seem to have inaugurated an entirely new state of things, and to promise well for the future. But there are also many features of the case which strongly suggest the backward state of things from which the present condition sprung, so that the old and the new can be traced side by side.

On the side of biology, a considerable share of recent development can be traced to the advent of Agassiz among us. The eclat of his European reputation evoked immediately on his arrival an amount of public attention and consideration which a native would have been a long time in commanding; while his remarkable power as a teacher turned the thoughts of many young men toward his favorite subject. Nor must his powers as a public lecturer be ignored. It is hard to calculate the effect which he produced on the public mind in this way, extending as it does far beyond the limits to which his immediate personal intercourse was confined.

What Agassiz did in biology was done by Mitchel in astronomy. All that he lacked in purely scientific ability and reputation was made up by his unrivalled power of charming the public by his descriptions of astronomical phenomena. If his name lacked the flavor of foreign birth and eminence, the defect was compensated by the interest and elevation of his subject, which was peculiarly fitted to interest both the highest and lowest class of intelligent hearers. It is not unlikely that he sowed much of the seed from which the American astronomy of the present has developed.

If we consider simply the appliances for astronomical research, and the number of persons in some way engaged in such research, the development of our astronomy during the present generation is something surprising. In 1832 Professor Airy made a report on the progress and present state of astron-

omy to the British Association for the Advancement of Science, in which he had to announce his inability to give any account of practical astronomy in America, because he did not know of a single active observatory in that country. In the beginning of 1840 there was not an observatory in the country which, in the completeness of its equipment, could claim to be greatly in advance of the private collection of instruments made by Rittenhouse sixty years before. The interest in astronomy taken by a few officers of the navy, the stimulus of the great comet of 1843, and the wide public interest in the subject which has in one way and another been excited, have altogether resulted in the building and partial or entire equipment of a far greater number of observatories than, with the limited funds at disposal, can be kept in operation. Highly as we must estimate the large views and public spirit which have prompted the erection of these establishments, we cannot but deplore the lack of sound knowledge which has resulted in such a waste of valuable means. If all the money thus spent in scattered efforts had been concentrated on two or three large establishments, it would have gone far toward making our country the foremost of the world in the science of astronomy.

The recent extraordinary progress to which we allude is not confined to special sciences, but may be said to include all the material facilities for the prosecution of research of every kind, as well as for the acquisition of a thorough scientific education. Our important chemical laboratories and our best scientific schools, with perhaps a single exception, are of an origin as recent as that of our observatories. If we study our museums and laboratories, and notice the activity manifested by the former in collecting everything which may illustrate the biology, ethnology, and archæology of this continent, and by the latter in the instruction of the young, we see the strong side of our science, the side on which we can look with unqualified satisfaction. If we feel any regret or humiliation on the reflection that it is not the growth of a century, and that during the greater part of our national existence we had nothing of the kind to show, the present can take to itself all the greater credit for having produced everything, while the rapid advance implied will render us all the more hopeful of the future.

Still confining our attention to the side thus presented, and considering the national energy which has been expended in its development, we might fancy ourselves rapidly approaching the day when we shall be the leading scientific nation of the world.

But when we turn from the material side to the side of ideas, when, instead of observatories, telescopes, laboratories, museums, explorers, we consider the progress of the literature and thought of science, the contrast is painfully astonishing. Far from seeing an advance corresponding to that of the material side, much industry and pains would be required to trace any great improvement. If we were to draw our illustrations of this entirely from the exact sciences, in which mathematics is the leading instrument of research, the comparison might not be considered entirely fair. Let us then take a subject within the capacity of every thoughtful mind. No movement in modern thought has been so revolutionary in itself, or so fertile in its results, as that which has been wrought by Darwinism. Probably as much interest has been excited in this country by this subject as in any other. The doctrine has made its way among our naturalists as it has among those of England and Germany, and its literature has probably as many readers here as in England. What, then, have been our contributions to this literature? We know of but three or four American writers who have contributed anything at all; two of them, Chauncey Wright and John Fiske, having done so in this Review. Except the "Cosmic Philosophy" of the latter, which embraces an extended review of a subject of which Darwinism is one of the most important parts, not a single independent work on the subject has yet been produced on this side the Atlantic. Of essays and reviews in periodicals, far the larger part have been the production of Mr. Wright and Professor Asa Gray. Its opposers on scientific grounds have been Professors Agassiz and Bowen, the latter having considered it as "the latest Form of the Development Theory," in the *Memoirs of the American Academy*. We believe this to be a complete list of important American contributors to the scientific thought of the subject, purely technical investigation of facts in natural history being omitted.

In this connection it may not be amiss to remind the reader that arguments designed to prove that Darwinism either is or is not subversive of religious belief, or to attack or defend it on religious grounds, cannot be regarded as contributions to the science of the subject; but that a work designed to prove on purely scientific grounds that the doctrine is untenable would not, on account of the side it espoused, be excluded. In literature of the former class it is not impossible that we might be able to make some showing.

When we compare the quantity of our literature of Darwinism with that of Germany, the contrast is astonishing. Not a year elapses in which the German press does not turn out a more extended philosophic literature of the subject than the American press can show during the sixteen years which have elapsed since the publication of the "*Origin of Species*." Turning from this discouragingly small quantity we may find relief and hope in considering the quality of our contributions. In philosophic comprehension, scientific accuracy, and clearness of thought, the essays of Wright and of Gray might well head the list in a competition among those of all nations.

What we have said of the literature of Darwinism is true of that of every branch of pure science. Not only is our scientific literature of every kind meagre in the extreme, but the facilities for the publication of any kind are extremely restricted, and have increased but little during the last fifty years. *Silliman's Journal* is now, as it was half a century ago, the solitary standard journal of pure science published in the country. There has been no increase in the means or the publication of our learned societies at all proportionate to the increase in the material facilities for research. How can we account for this? Why should not the vast increase in the means of research have been accompanied by a corresponding increase in scientific publications and discussions? The answers to these questions depend on a variety of circumstances, some of which are connected with the general state of scientific thought here, while others can be brought out only by a comparison of our resources for publication with those of other countries.

In other intellectual countries a large portion of the published



scientific research appears in the transactions of learned societies. A comparison of the means at the disposal of our societies and those of other nations will at once explain a part of the difference. On the Continent the learned societies are under the immediate patronage of their respective governments, by which the expense of publishing their transactions is borne. In this country we are aware of but a single State which has thus taken upon itself the patronage of science, and it will probably surprise many readers to hear that this is Wisconsin. It is not impossible that there are other States which have done the same thing, but, if so, we have not become aware of the fact.

Deprived of State aid, our societies must depend upon their limited resources for the means of publication. The meagreness of these resources is in most cases extremely surprising when we take into consideration the wide-spread interest in science, and the ease with which associations of all sorts, except the scientific, can raise money to promote their ends. Sums are invested in a single horse or yacht race which all the scientific societies of the country could not collect in a year. There are probably not more than three or four of these societies whose entire annual income would furnish the stakes for which a pair of first-class pugilists ordinarily fight; we are not sure but that it would be an over-statement to assert that there is a single one so rich. It must be admitted that there are points of view from which our claims to be an intellectual nation look very slender indeed. We cannot but hope that the subject of aiding learned societies to publish their researches will receive more attention from our State governments in future. And we may here remark, that the more enlightened foreign governments do not confine their assistance to such societies; but also, to some extent, patronize journals of abstract science which are published by individuals. There is perhaps no one agency which has, during the last half-century, contributed so much to the advance of mathematical science in Europe as the mathematical journal established by Crelle in Berlin. Yet it could hardly have been continued, — but for the support given it by the Prussian authorities.

Were we to inquire closely why our State and general gov-

ernments have been less effectively active in the promotion of science than those of other countries, we should probably find it to be, not because there was any less disposition to be liberal in this direction, but because there is so little general understanding of the needs of science, and of its relations to the public welfare. This again may be partly due to the comparatively wide separation which exists between the political and business classes of our community on the one side, and the literary and scientific classes on the other. It is decidedly rarer in this country to see a man actively engaged in public life taking an active interest in the progress of science than it is abroad. In England many of the leading men of the nation are fellows of the Royal Society, attend its social if not its scientific meetings, and take an interest in its general welfare. Here, science is considered as forming a sort of priesthood, into whose mysterious circle a politician would hardly more think of penetrating than he would of ascending the pulpit. The only exception is seen in the reunions of the American Association for the Advancement of Science, a large and popular body, which are frequently attended by public men residing near a place of meeting.

If there really were such a priesthood of men of science, if we could show an influential body of men earnestly working together in the pursuit of a definite object, the case would be much better than it is. A united body of men, possessed of the general ability of our scientists, and working earnestly together, could not fail to make itself felt. In fact, however, we do not find in our country, within scientific circles or outside of them, a collective body or class of men taking such a deep interest in American science for its own sake as the great body of intellectual men in other lands take in the science of their respective countries. Individuals who take such an interest are numerous enough, but hitherto they have been mere isolated, inactive men, too much scattered to act in concert in any way. When we look abroad into other intellectual countries, we find the case to be entirely different. In France, in England, and in Germany there are bodies of men possessed of social, political, and money-raising power who take pride in the intellectual progress of their respective countries, and, by their united ac-

tion, exert a powerful influence in inciting scientific investigators. One or two illustrations of the wide difference between our own country and England in this regard will make our meaning clearer than pages of general description. In the latter country one of the functions of scientific societies, and indeed the function in the performance of which the widest interest is taken, is that of furnishing information respecting the progress of science, and the labors of scientific investigators. A pardonable patriotism, accompanied by a desire to please their hearers, results in the speakers or writers on such occasions dwelling principally on the labors of their fellow-countrymen. The one-sidedness of these addresses or reports not unfrequently calls down severe criticism from foreigners, on account of extravagant claims made for English science; but a sufficient answer to such criticisms is found in the fact that the utterances complained of are intended for audiences purely English, met to congratulate each other on the progress of English science, as well as of science in general.

A German would be ashamed to avow any such bias toward the labors of his own countrymen. In describing the progress of knowledge he is careful to divide the credit among those to whom it is due, regardless of nationality, desirous that no one should be able to infer the country of its origin from the names of those whose labors he describes.

In America there is no authority and no publication to which the public can look for authoritative information of this kind. It has always been the duty of the retiring president of the American Association for the Advancement of Science to make an address, but it has not generally been devoted to a review of scientific progress, either in America or elsewhere. An exception was however made at the Hartford meeting in 1874, when the officer in question delivered an extremely well-written essay on the progress of physical science in recent times. But, instead of being biassed after the English fashion, or impartial after the German, he carefully avoided all mention of the labors and researches of his countrymen. A hearer would have inferred that there was absolutely no such thing as American science. Some of his subjects, such as sound, the velocity of electricity, spectrum analysis, and astronomical research

counted Americans among their most successful cultivators, yet they were entirely ignored. If they were few in number and not so well known here as abroad, there was so much the more reason for giving prominence to their works. Such an address before the sister society of Great Britain would have been impossible, from a wholesome fear on the part of the speaker of being mobbed by the newspapers, if from no other reason. The point which we have in view, as illustrative of the greatest drawback with which our science has had to contend, is not, however, the delivery of the address, but its reception by the press and the public. The literary merits of the production were such as to secure for it a wide circulation, and some favorable comment from the press, but not the slightest notice of the way in which American science was ignored was taken in any quarter whatever. Not a voice inquired whether science was entirely a European production. Among the listeners and the readers the logical conclusion that our country had not during its whole history produced anything worth notice was accepted as too much a matter of course to excite even a passing thought.

A striking example of energy and enterprise is found in the fact that it has been reserved for the American Coast Survey to make the latest and best determination of the difference of longitude between the two oldest of the great observatories of Europe, — those of Greenwich and Paris. This determination was a mere incidental result of the determination of the Transatlantic longitude, but is not on that account the less important. Two determinations of the longitude across the Atlantic, the one from Greenwich and the other from Paris, were found to be discordant, and when the third side of the triangle, Greenwich-Paris, was measured, it was found that the discordance was due to the error of the former measurements of that side. In other words, the longitude of Paris found by telegraphing across the Atlantic from Greenwich, and then back again to Paris, was more accurate than that which had been formerly found by telegraphing directly between the two cities. Now, let us turn the shield round and look on the other side. The combined skill and diplomacy which rendered the project successful — for one can readily conceive that a little diplomacy was

necessary in such an affair — have never received the smallest recognition from our public. When the men who did the work landed on their return home, there was no committee to receive them, as there would have been had they been successful shooters ; not even the most enterprising reporter found them out. There has never been a trace of the unseemly national glorification in which it is sometimes supposed that our countrymen are wont to indulge. The history and results of the expedition are duly immured in the proper official volumes, but have never made their way out of them, into the public prints, except, possibly, into the fine type of a Tribune extra. The number of people who ever heard of the work are too small to constitute a public, and the number who still remember it are yet smaller.

We must not conclude from all this that no interest in science is taken by the American people, but only that that interest does not manifest itself in such a way as to promote scientific research. The great success of several popular scientific publications, especially of the cheap ones issued by the New York Tribune, shows that there must be a large body of readers who eagerly buy that class of literature. It would be of interest to know precisely among what classes of the community these readers are divided. Taken in connection with the absence of interest in the subject shown by men in active life, there is some reason to suppose that the classes in question would be found, for the most part, to be neither the influential nor the best educated. If the statistics of the subject were attainable, it would perhaps be found that the amount of intelligence best calculated to lead men to seek after knowledge in this direction corresponded to that necessary to excite the sentiment of wonder. The entirely ignorant necessarily care nothing for the subject, while the most highly educated have been so familiar with it, at least in some of its aspects, that it has not for them the charm of novelty. Between these two classes we can easily conceive of one to whom the discoveries of the chemist and the astronomer, when stated in untechnical language, read something like a fairy-tale.

The drawbacks to the advance of science which we have described are the same as those which everywhere in our nation

have impeded the development of the highest types of thought. Our national thought lies very much on a dead level; its lowest forms are much above those of other countries, its highest below them. While the small tradesman of England is, in breadth of views, far behind the small tradesman of America, the men who aspire to the leadership of public opinion, taken as a class, diverge in the opposite way. It is not only in physical science we see this, but in the general application of scientific methods to the affairs of life. Here, as elsewhere, so long as only plain common-sense is required, we find ourselves well in advance, while we are further behindhand the further we look into questions requiring a higher form of reasoning. There are few applications of scientific method which have been of more lasting benefit to mankind than the modern political economy, and none which have done so much to diffuse American ideas of government and society. It would have been both pleasing and appropriate to have seen it a product of American thought. But, far from anything like this being the case, it is doubtful whether we can claim that an important contribution to it has ever been made on this side the Atlantic. We have a number of elementary treatises on the subject, some of them of a very excellent kind, but none of them make any pretensions to being original contributions to the knowledge of the subject. Our only writer who has ever created even a ripple on the surface of economical thought is Mr. Carey, and his methods and results are so different from those by which the science has been developed, that it is difficult to give him a place among the economists. Such a place can be fairly assigned him only by confining ourselves to the subject-matter of his researches, and ignoring his methods as unimportant. The proportion of our readers whose opinions of his system are not fully formed is so small, that a detailed criticism of that system would be of little account here, if it were not entirely out of place. We mention him because our choice lies between taking him as the great representative of American political economy, or admitting that we have no system of political economy to call our own.

As a result of our survey, it will be seen that we must form very different estimates both of the past and future of Ameri-

can science, according to the standard we test it by, and the standpoint from which we view it. When we inquire into the wealth and power of our scientific organizations, and the extent of their publications, — when, in fact, we consider merely the gross quantity of original published research, — we see our science in the aspect best fitted to make us contemplate the past with humility and the future with despair. But when we consider quality as well as quantity, we may begin to take courage, for we find that the proportion of valueless or unimportant matter is far less than abroad. A study of the case will show that this arises from the same cause to which the small amount of original research is due, namely, the fact that the rewards of real eminence are less here than abroad. The necessary result is, that Nature is studied more for her own sake here than elsewhere, and that there is less competition among men who are striving for mere position or popular reputation. To whatever extent the deficiency of such rewards may deter first-class men from original investigation, it acts much more strongly against second-class men, and thus improves the average quality of our science. If, again, we consider the intellectual energy shown by our ablest men, and, we might almost say, the national energy with which science has been pursued in certain directions during the last thirty years, it might seem entirely feasible to make our country the leader of the world in science at no very remote day. What are the conditions of such a consummation, and what are the prospects of those conditions being fulfilled? Our scientific forces present somewhat of the aspect of an army with plenty of health and courage, and possessed of ample munitions of some kinds, while totally wanting in others, because it has been fitted out by a government very liberal of its money, but totally ignorant of the wants of an army. Each company fights splendidly on its own account, but the army at large is ineffective, from the want of leadership and discipline. The public at large knows very little about the fighting, and, in apportioning rewards is more influenced by the military aspect of a soldier's whiskers than by his deeds in battle. The basis of our requirements is a better knowledge of the wants of science among those who give money for its promotion. On the ma-

terial side we want nothing new at present; we require no increase in the number of our museums, observatories, or laboratories during the present generation. What we do want can be seen by studying the logical connection of our several deficiencies, as we have sought to point them out. We are deficient in the number of men actively devoted to scientific research of the higher types, in public recognition of the labors of those who are so engaged, in the machinery for making the public acquainted with their labors and their wants, and in the pecuniary means for publishing their researches. Each of these deficiencies is, to a certain extent, both a cause and an effect of the others. The want of public recognition and appreciation is due partly to a want of system and organization, partly to the paucity of scientific publications. The paucity of research is largely due to the want of adequate reward in public estimation and recognition; while the paucity of scientific publications is due to the want of an adequate number of supporters. The supply of any one of these deficiencies would, to a certain extent, remedy all the others; and until one or more are so remedied, it is hopeless to expect any great improvement. In other intellectual nations, science has a fostering mother, — in Germany the universities, in France the government, in England the scientific societies; and if science could find one here, it would speedily flourish. The only one it can look to here is the educated public; and if that public would find some way of expressing in a public and official manner its generous appreciation of the labors of American investigators, we should have the best entering wedge for supplying all the wants of our science. The precise form which such a recognition should take is comparatively unimportant, but the most natural one would seem to be that of medals or testimonials to be awarded from time to time to the authors of important published researches. The testimonials should have as much of a national character as possible, and should not be so few in number as to discourage the great mass of investigators from competing. Indeed, it might be well if the encouragement of beginners was made their principal object.

The other way in which help could be most effectively given at small expense is by the support of two or three first-class



journals of exact science. We say exact science, because this is the department which is worst supplied in this respect; taking mathematics at one extreme and medicine at the other, we can pretty accurately gauge the exactness of each science by the difficulty its cultivators find in supporting journals devoted to it. It may seem like reducing our thesis to the ridiculous to say that our wants in this respect could be well supplied at a cost of five or six thousand dollars per annum, and that the future prospect of the mathematical sciences in this land depend very largely on their cultivators being able to command this annual sum for the purpose indicated.

On the whole, we have not been able to present the first century in roseate colors; and while we can well contemplate the future with hope, we cannot do so with entire confidence. If we ask what this signifies, we are at once led into questions which the thinker and the man of action may discuss indefinitely, but to which no answer can be returned which will command universal assent. It is admitted that if we consider only the general excellence and success of our applied science, if we reflect how well we have utilized the discoveries made by others, by developing them into railways, bridges, telegraphs, manufactures, machinery, and weapons of warfare, we have every reason to be well pleased with our success. Is this not enough to satisfy us? The standing of nations in the world depends solely on the effectiveness of their cannon, and will long continue to do so; the intellectual nations are foremost only because they know best how to forge cannon. Is it, then, worth our while to set up any other standard to measure ourselves by? To take a little higher basis for our inquiries, the fundamental idea of our social system is the greatest happiness of the greatest number, and if the intellect of the masses is developing satisfactorily, can we not dispense with philosophers of every description? Suppose the higher types of exact thought should disappear entirely from among us, is there any danger that sudden calamity would overtake us, or slow decay undermine our national life? Or if, ascending above all considerations of mere utility, we inquire into the intellectual status to which, as a nation, we are entitled, ought we to draw any unfavorable conclusions from a deficiency in the higher

forms of thought? It may be claimed that the number of men in each generation who can make a permanent impression on the literature, science, or art of a people are necessarily very few in number, so few, in fact, that their presence or absence is hardly felt in estimating the average intellect of the nation. The fact that the score or so of men necessary to enable our country to make a brilliant intellectual showing may not be found, does not in any way militate against the average intellect of the twenty or thirty millions who live in it. From this point of view, a nation in which every one, from the legislator to the day-laborer, could read and appreciate Plato, would be, intellectually, the greatest nation of the world, though it could not show the beginning of an intellectual life peculiar to itself. A community in which every man had a good grammar-school education would, from the same standpoint, be the best educated in the world, though not a member of it had ever seen the inside of a college.

To dispute the question what intellectual status should be assigned to communities such as these would be were logomachy, and to question the desirableness of a state of things in which every member of the community, however humble, should be thoroughly educated, would be running counter to that idea of the universal diffusion of the highest means of happiness on which our society is based. Still, while in no way decrying a state of society in which every ploughboy could read Plato, we must point out that all the wants of our civilization would not thus be satisfied. In the complex operations of that civilization we may see the same necessity of a division of labor, and the same absence of necessity that any one man shall be able to do everything, that we see in the operations of mere industry. In a factory, the highest efficiency is reached when each kind of productive faculty is employed in the proper proportion, from the skill of the single managing head to that of the thousand operatives. In the same way the proper advance of our civilization requires the harmonious co-operation of minds of many orders, each present in the proper number. Its operations are most effectively performed when every member of society is able to perform his peculiar duties to his fellow-members in the most effective

way, and in which some one is found to perform every function necessary to the progress of the whole. However desirable it may be that each individual should be able to do as many things as possible, the requirements of society at large do not extend beyond the limits we have indicated. That nation will advance most rapidly in which the statesmen have the strongest intellects and the navvies the strongest bodies. There is no more need that the latter should have the heads of statesmen than that the former should be able to handle the spade.

We may now see that while the neglect of philosophic research which we have pointed out may not diminish our judgment of the average American intellect, it does indicate a great want of one of the factors of our civilization. Scientific research, and the presence of those ideas on which civilization is founded, are so closely connected, and each is so productive of the other, that they cannot be separated. The fact that a very small number of investigators are sufficient to build and maintain the science of a country, should not blind us to the importance of their work. If we could count the men whose death in their cradles would have resulted in the continuance of the Dark Ages to the present time, the original minds whose thoughts have leavened our whole lump, we should find it to be fearfully small. The fact that their number is small, and their influence exerted in ways so occult to the ordinary mind that they cannot be traced, naturally leads to a general under-estimate of the importance of their functions. In visiting a factory, the superficial observer sees only the outward operations of the establishment, and may be easily led to believe that mechanical labor is the only important agency in its inception and continuance. The business skill of a few men, without which a large fraction of the operatives might have been running the streets in idleness, or engaging in less remunerative labor, lies far in the background of his field of vision. Still further back lies the skill of the inventor who devised the mechanical operations he witnesses, while the genius of the physicist who discovered the natural laws on which the invention is founded is entirely beyond his range.

Not dissimilar are the views of the various elements of our social organization taken by those whose breadth of knowledge

and depth of understanding are not such as to enable them to trace all the causes at work in society. We are familiar with a class who see nothing in society, or at least in its industrial operations, beyond the work of the physical laborer. Another class, of a wider range of vision, can see the functions of the organizer and the capitalist, without whom the means to make labor effective would be entirely wanting. The class who can fully grasp the functions of the purely intellectual laborers is yet smaller. Not because intellectual laborers are entirely unappreciated by the public at large, but because an incorrect view is taken of their functions. To the average intelligent citizen philosophical thought and scientific research, when not immediately directed to some obvious practical end, are mere ornaments, the trimmings in fact of the social edifice. They may be ornaments with which he would not willingly part; still it is only as ornaments that he values them, and if something must be lopped off, he is too apt to let them go first.

Among the fallacious ideas which pervade society, there are none the dissipation of which is of more importance than the one thus formed of exact thought. No want from which our nation suffers is more urgent than that of a wider diffusion of the ideas and modes of thought of the exact sciences, and nothing is more fallacious than to look upon the results of such thought as purely ornamental. A large fraction of our public occupations consist in examinations and discussions of social phenomena, in which no certain result can be obtained without a logical exactness of investigation to which every-day life is an entire stranger. Each generation is determined to examine for itself the foundations of society and of government, and is strongly disposed to tear away as rubbish everything which seems to impede progress and of which it does not see the utility. To what dangers may we not be exposed if the renovation is undertaken by unskilled hands, directed by men who are not only ignorant of social laws, but incapable of exact reasoning of any kind whatever! What is required to insure us against disaster is not mere technical research, but the instruction of our intelligent and influential public in such a discipline as that of Mill's logic, to be illustrated by the methods and results of scientific research. The present great move-

ment in favor of scientific education will be productive of one excellent result, if it serves to direct the minds of the rising generation toward the methods of science, and the ways in which those methods must be applied to the study of societary laws rather than to the technicalities of science, or to its practical applications to the ordinary operations of industry.

The most superficial observer cannot fail to see that there is some want of the kind we are indicating to be filled. He sees statesmen, orators, newspapers, and magazines discussing the currency question by hundreds every day. He knows that their words fall dead upon the ear of the public, for the simple reason that the speakers and writers cannot convince the public that they have any real knowledge of the subject, or any clear understanding of the questions involved. In this way the entire ineffectiveness of the great mass of the arguments is quite clear to him. What he sees very dimly, or not at all, is that the deficiency arises from the want of any systematic logical method in the processes by which the disputants reach their conclusion, while the way in which such a method is to be mastered lies quite beyond his vision. If he sees the way, he certainly will not consider philosophic thought as a mere ornament.

From this point of view science presents itself as a system of national liberal education, to be maintained for the same reasons that we maintain the liberal education of the individual. Without it we shall suffer precisely as the individual suffers when he follows a profession of which he does not understand the first principles. We must look to the cultivation of science in its broadest fields to do for the future of the nation what a knowledge of mathematics does for the engineer, of chemistry for the physician, or of mechanics for the architect. Its function is not merely to furnish empirical rules for our guidance, but to shed the brightest possible light upon a difficult path, in which we are to make our way by our own best judgment. With it, the path may sometimes be hard to find; but without it, we must grope entirely in the dark.